MASSACHUSETTS FARM

Energy

Best Management Practices for Renewable Energy

Massachusetts Farm Energy Program

Conservation • Efficiency • Renewables

MASSACHUSETTS FARM

Energy Best Management Practices

Berkshire-Pioneer Resource Conservation & Development Area

GDS Associates

Massachusetts Department of Agricultural Resources

Massachusetts Farm Energy Program

USDA Natural Resources Conservation Service

Amherst, Massachusetts · 2010

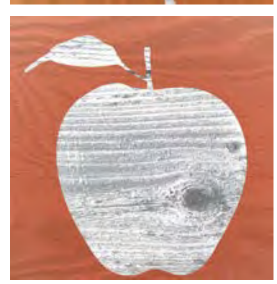
MASSACHUSETTS FARM ENERGY GUIDES BY FARM SECTOR

Please note that this guide is part of a series of farm energy Best Management Practice guides available for the following sectors and topic areas:

Dairy Farms

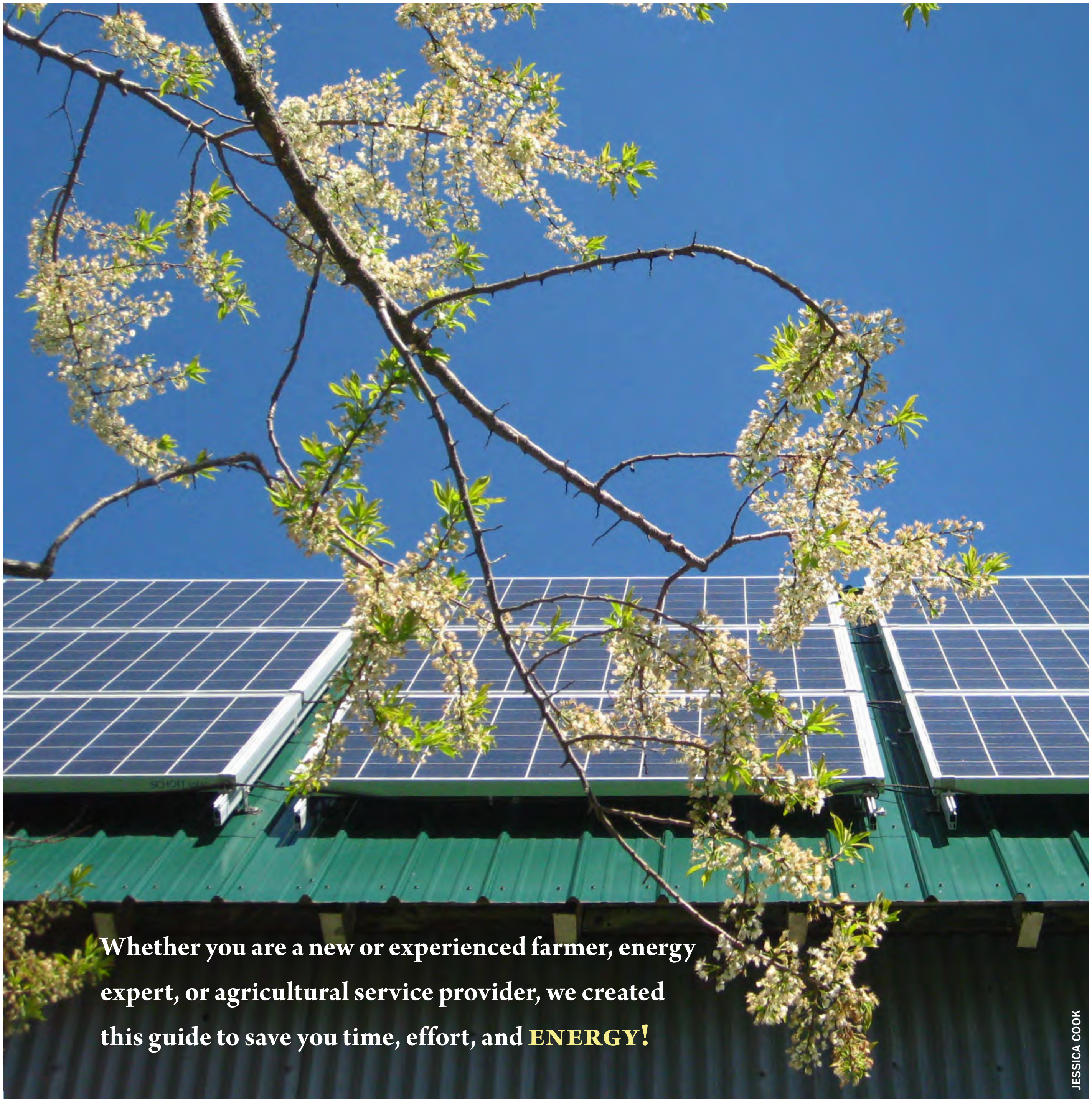
Greenhouses

Maple Sugaring



Orchards & Vegetable Farms

Renewable Energy


Whether you are a new or experienced farmer, energy expert, or agricultural service provider, we created this guide to save you time, effort, and ENERGY!
JESSICA COOK

Welcome to the Massachusetts Farm Energy Best Management Practices Guide

Practical solutions & entry points

This guide is about practical steps you can take immediately, with a focus on the most common and cost-effective equipment upgades and systems currently available for farms in our region.

For farmers who are managing a constant flow of weather events and day-to-day business needs, we offer an entry point to on-farm energy savings and renewable systems that make use of the technical skills and systems-thinking of our local community.

Thinking of systems from the start

The farm energy guide is organized by sector, focusing on retrofits that work for existing farming operations. However, farmers can also apply the guidance provided in these pages to incorporate energy issues into the planning and initial design stages of new agricultural businesses.

There is an increasing amount of interest in energy amongst the state's farmers, and examples in this guide can provide a launchpad for more innovative energy systems in the future.

JESSICA COOK

Sometimes you just need a place to start— —based on good information and solid economics.

We hope that by breaking things down by process or technology—looking at average savings and commonly recommended measures—we offer readers a place to start their projects.

We know for many farms economic feasibility is the first question when it comes to on-farm energy projects—is the investment worthwhile?

We have highlighted estimated payback periods in the following pages, identifying the number of years an upgrade will take to pay for itself.

While we calculate the dollar savings in fossil fuels or other energy sources, it's important for you to consider other benefits on the farm, such as reduced farm labor or increased sales resulting from greener systems.

The examples in this guide are drawn from real life, based on averages across farms in Massachusetts who have worked with MFEP, so payback numbers are directly applicable to the scale of farms in our region.

Encouraging climate and resources

Forward-thinking energy policies at the state level have combined with supportive agencies and utility programs, financial incentives, and good partners to provide fertile ground for farm energy projects in Massachusetts.

We are enthusiastic about the energy future of the agricultural community in our region, and acknowledge the motivated farmers who are open to sharing their experiences, willing auditors, and proactive installers who are getting projects up and running.

We encourage you to take advantage of these key resources to move ahead with your own farm energy project!

— the Massachusetts Farm Energy Program team

Acknowledgements

This farm energy best management practices guide was compiled and written by GDS Associates, Inc. (GDS) for the Massachusetts Farm Energy Program (MFEP). Specifications and recommendations in this document are based on industry-specific research and informed by the audits and projects implemented with the assistance of the Massachusetts Farm Energy Program (MFEP) between 2008 and 2010.

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Introduction

The *Massachusetts Farm Energy Best Management Practices Guide* provides the Commonwealth's agricultural community with resources and methods to reduce energy use and produce renewable energy on farms. These recommended on-farm energy upgrades improve farm viability and minimize the environmental impact of the agricultural industry in Massachusetts by reducing energy consumption, operating costs, emissions, and dependence on fossil fuels.

These guides focus on conventional energy best management practices (BMPs) - cost-effective practices that offer significant environmental and economic benefits - for the four primary agricultural sectors represented in the Commonwealth: greenhouses, dairy farms, orchards and vegetable farms, and maple sugaring. It also covers considerations for on-farm renewable energy options, including wind, solar thermal, solar photovoltaic and biomass.

This document aims to be a practical resource for farmers and service providers alike, organized to help readers understand farm energy use, evaluate potential equipment upgrades, and prioritize energy efficiency and renewable energy opportunities. The information in this guide can also be used to inform policy, technical assistance programs, and government agency and public utility cost-share programs for energy efficiency and renewable energy on farms.

The information in this guide is based on industry-specific research and Massachusetts Farm Energy Program (MFEP) data from more than fifty energy projects implemented between 2008 and 2010. For areas not covered in this document, additional information can be found by contacting the Massachusetts Farm Energy Program (MFEP).

Environmental Impact of Energy Use

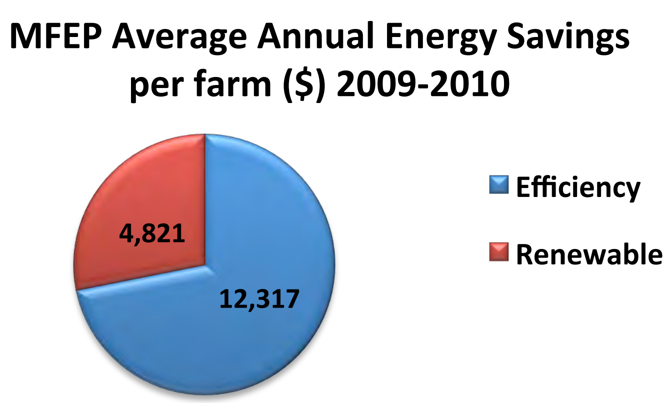
Energy conservation and renewable energy systems on farms can help reduce the use of fossil fuels and related greenhouse gas emissions, and mitigate the contribution of Massachusetts agriculture to point-source pollution and global climate change. Massachusetts' farmers can set an example for other industries in the region by making viable business decisions that improve operations and profitability while reducing negative environmental impacts of "business as usual". MFEP's experience illustrates farms' improved environmental performance - through reduced carbon dioxide emissions – as a result of energy efficiency and renewable projects.

Economic Benefits of Energy Savings

New England farmers pay 23-56% higher rates for energy resources than the U.S. average. As farmers identify the source of their energy demand and make improvements to their systems, they can reduce their dependence on fossil fuels and improve their bottom line. MFEP's work with has assisted farmers do exactly that, thus having a direct impact on the financial viability of many Massachusetts farms.

The average net income of a Massachusetts farmer is just over $12,000 according to the National Agricultural Statistics Service. At the same time, average annual energy savings from farm energy efficiency projects facilitated through MFEP average out at $12,000 per farm (see chart below), thus making energy efficiency improvements a sound business decision that can have a significant impact on overall farm viability. The economic benefit of these savings is further multiplied as farmers reinvest in the local economy in a variety of ways as they maintain and build their businesses.

It is important to note that energy projects results in different rates of financial returns for farms, either through reduced energy use or offsetting fossil fuel use with renewable energy. Renewable projects can work out favorably in terms of overall return on investment for farms, particularly with the support of grant and payment programs. However, efficiency projects save 2.5 times more energy on average than renewable systems generate per dollar invested.



About the Massachusetts Farm Energy Program

What is the Massachusetts Farm Energy Program?

The Massachusetts Farm Energy Program (MFEP) is a full-service program for technical and financial assistance for farmers and agricultural businesses. It is a statewide collaborative effort, bringing together federal, state, industry, and private support to streamline resources available to Massachusetts farmers in order to 1) increase on-farm energy conservation and efficiency, 2) promote alternative and renewable energy strategies for on-farm energy generation, 3) improve farm viability by reducing energy consumption and costs, and 4) reduce agricultural greenhouse gas emissions. MFEP is a joint project between the following partners:

- Massachusetts Department of Agricultural Resources (MDAR) www.mass.gov/agr
- USDA – Natural Resources Conservation Service (NRCS) www.ma.nrcs.usda.gov
- Berkshire-Pioneer Resource Conservation & Development Area (BPRC&D) www.berkshirepioneerrcd.org

MFEP has offered a range of services to the farming community, including technical assistance, audits and consultations, financial incentives, and facilitation to leverage funds to bring projects from initial concept to implementation.

Why MFEP?

Electricity and fossil fuel costs have increased by approximately 30% in the last few years. The impact on farms has meant a dramatic increase in costs related to power, refrigeration, heating, ventilation, lighting, transportation, fertilizer, and feed. Rising energy costs reduce profit margins for all farmers and directly threaten the viability of farms across the Commonwealth.

The agricultural community has not maximized energy savings in part due to challenges in navigating an ever-changing landscape of support programs. MFEP streamlines these resources and provides direct technical assistance through energy audits, renewable energy assessments, and incentives for implementation of audit recommendations, including those recommended by public utility programs. As a result of complex partnerships between farm business owners, government agencies, for-profit practitioners, and public programs – farm energy upgrades are contributing to the region's environmental goals and stability and resilience of our agricultural communities.

agricultural sector can be found at www.berkshirepionerrcd.org/mfep.

Best Management Practices for Renewable Energy

In Massachusetts many farms are installing renewable energy systems to match their farming and environmental ethic, appeal to their market base, improve long-term economic viability, increase energy independence, and provide an example and educational opportunities for their communities.

In this section you will find the following best practices:

- Biomass for Heating (Hydronic Heaters)
- Solar Thermal (Solar Hot Water)
- PV Solar Electric (Photovoltaic)
- Wind (small to medium-scale)

It is important to focus on energy conservation and efficiency prior to considering renewable energy. Energy efficiency is typically the most cost-effective means of reducing your electrical energy needs and provides the best return on investment. By reducing your energy needs, you can downsize the renewable energy system to offset energy production, reduce up-front costs and make renewable energy more feasible.

Since renewable energy is typically a higher-cost investment, it is always recommended to work with a professional to complete a site assessment and a feasibility study. When considering what type of renewable energy is best suited for your site, needs, and goals, consider the following:

- **Biomass:** Ideal for anywhere space heating and water heating is currently being done with fossil fuels. There are permits that are required, but they should be easy to obtain as long as new "white tag" qualified models are installed. These models are cleaner and more efficient than non-qualified models. The most common and successful biomass application is for space heating in greenhouses, but biomass applications are also appropriate for many other space and water heating needs.

- **Solar Thermal:** Ideal for augmenting or replacing water or space heating currently being done with fossil fuels or electricity. It has been proven to be most economical for replacing water heated with electricity. Solar thermal systems are typically designed to offset about 40-60% of hot water needs. Winter solar radiation can be less than half of the summer solar radiation. This means inconsistent heating throughout the year, and therefore, a backup heater is often required. Solar thermal systems are passive and have very few moving parts, meaning they have a long rated life (25+ years) and have proven to work successfully and provide a high return on investment.

- **Solar Electric:** Ideal for offsetting any of the electrical production of a facility and for remote applications that don't have access to electric power. Solar electric has been used successfully in all agricultural sectors that use electricity. In Massachusetts, most systems are hooked up to the grid using net-metering so energy production and Time-of-Use does not have to match up. Solar electric systems are passive and have very few moving parts, meaning they have a long rated life (25+ years), have proven to work successfully and provide a high return on investment.

- **Wind:** Ideal for open spaces, ridge tops, and coastal areas where wind speeds are higher and proven to be sufficient for successful wind energy production. Most systems are hooked up to the grid using net-metering so energy production and Time-of-Use does not have to match up. Consideration of all necessary local zoning, ordinances, and/or permits is vital for wind projects

Best Practices for Renewable Energy - Biomass

Technology

Biomass for Heating – Hydronic Heaters

Source: www.centralboiler.com

At a Glance:

- New qualified units are 90% cleaner and more efficient than unqualified models
- Unit must be certified and meet regulations from MassDEP
- Can be used for space heating and hot water
- Cost-effective, safe, and environmentally responsible

Background

Biomass is a fuel derived from organic material of recent biological origin. The following feedstocks can be used:

- ***Wood*** can be cut, split and dried as cord wood or chipped for larger boiler units.
- ***Crop Residues*** such as corn fodder or wheat straw can be used. Crop residues are typically pelletized.
- ***Grains*** such as corn or switchgrass can also be used. Grains need to be dried before they can be used as fuel.
- ***By-products*** such as wood shavings and sawdust can be pelletized for fuel.

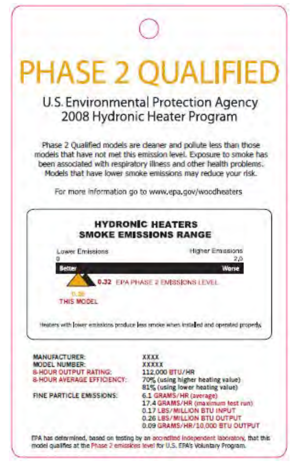
Biomass fuel can be used to supply hot water, for space heating, or for process heating such as in an evaporator for producing maple syrup. Units using biomass fuel can be located indoors or outdoors and can use a conventional fireplace, wood stove, furnace, or a boiler. Hydronic heaters, such as the outdoor wood boiler (OWB), are one of the most common types found on farms and will be a primary focus of this best practice. Arch furnaces for maple syrup operations will also be presented.

Due to recent efficiency improvements and emissions reductions, high efficiency gasification biomass furnaces and boilers have become popular, both from an economical and environmental standpoint.

The State of Massachusetts undertook a woody biomass study in 2010 to re-assess this resource's sustainability and carbon reducing potential. As a result, it was determined that woody biomass must be sustainably produced and harvested and used in maximum efficiency applications to be considered an eligible renewable energy. These applications include: combined heat and power (CHP) for electrical production and advanced combustion furnaces and boilers for thermal applications.

Best Practices – Biomass

Hydronic heaters are generally located outside the building. Most units use cord wood as their feedstock (though they may use other biomass fuels such as corn or wood pellets) to heat a fluid (water or a water/antifreeze mix) that is piped to the facility to provide thermal energy for space heat and hot water.



1. In recent years, boiler manufacturers have introduced new boilers to meet the EPA's new voluntary program that encourages manufacturers to develop and distribute cleaner-burning and more efficient units. These units are identified with a "white tag" label. The Massachusetts Department of Environmental Protection (MassDEP) has issued regulations that outdoor hydronic heaters for sale and installation in Massachusetts must be state certified through an application process meeting MassDEP regulations. A list of regulations and approved boilers is on DEP's website: www.mass.gov/dep.[i] Qualified models are about 90% cleaner than unqualified models and have improved efficiencies which reduce not only emissions but also the volume of wood that must be burned, reducing labor and costs.

Benefits

- Cost-effective, safe, and environmentally responsible heating solution to reduce heating costs compared to natural gas or propane
- Reduced carbon emissions compared to using fossil fuels
- Local, renewable energy source helps keep jobs in Massachusetts and reduces the state's overall energy deficit
- New EPA qualified "white tag" models are 90% cleaner and more efficient
  - Less particulate matter and pollution means better local air quality
  - Use up to 25% to 70% less biomass fuel compared to old models
- "White tag" models display their rated heat output, efficiency, and annual average emission rate, so it's easy to compare models side-by-side
  - For model comparison please refer to: http://www.epa.gov/burnwise/owhhlist.html

Biomass fuels used in a hydronic heater can be used for the following applications:

- Heat and hot water for homes, barns, or shops
- Greenhouse heating
- Any other application where heat or hot water is used

Applications & Limitations

Hydronic heaters using biomass fuel may not be applicable if a facility has limited heating needs. An inventory should be done of total BTU usage and BTU/hr for sizing to determine if a hydronic heater is economically feasible. Be sure to consider all local zoning requirements and permits for any limitations on using hydronic heaters. Most towns will allow them by a special permit, referring to DEP regulations 310 CMR 7.26 and to the DEP approved equipment list.

Best Practices – Biomass

Best Practices

Assessment
It is recommended that a professional be consulted to conduct an assessment or feasibility study. A proper analysis can provide the following information:

- Point out energy efficiency and conservation measures
- Determine maximum necessary heat load (BTU/hr) to help size the system and annual fuel usage used for heating
- Provide a life cycle cost assessment and help with available incentives
- Help secure a contract for a supply of biomass fuel (if not using a fuel source found on-site)

A life cycle cost assessment should include the following: implementation cost and project life, energy offset and boiler efficiencies, fuel cost and inflation comparison, operation and maintenance costs, available rebates and grants, and loan information (if necessary).

Assessments should be performed by a third-party, not the biomass or furnace supplier. Due to the variability in LP and natural gas costs, economics can shift each year. A long-term analysis of fuel price indices should be used in the analysis.

Energy Conservation
Energy conservation is the first step in every biomass project. It can reduce the heating load of the facility, reducing the initial cost of the system and increase burn time, meaning less biomass fuel consumption and decreased labor. Please refer to the other best management practices for information relating to energy efficiency for a particular sector.

Selecting Equipment
Only purchase a hydronic heater that is MA Certified and installed under MassDEP Regulations 310 CMR 7.26(50)-7.26 (54). For a list of Massachusetts certified models, please refer to:

- http://www.mass.gov/dep/air/community/certohh.htm
- http://www.mass.gov/dep/service/regulations/ohhregfl.pdf
- http://www.epa.gov/burnwise/owhhlist.html

Recommendations

- **Consider all necessary local permits including your local Board of Health.**
- **Focus on efficiency and conservation first.**
- **Only purchase heaters that are MassDEP certified and install in strict accordance under 310 CMR 7.26.**
- **Be aware of available financial incentives, rebates, and grants.**
- **Consider where you are going to purchase biomass fuel (if necessary) and try to secure a long-term contract to secure price stability.**
- **Consider required labor and maintenance for a biomass system.**
- **Follow all outdoor wood furnace best burn practices**
  - **http://www.epa.gov/burnwise/bestburn.html**

Best Practices – Biomass

Energy Savings

It is advised to have an expert determine potential energy savings based on actual values. For an approximation, refer to the online biomass combustion tool from USDA located at: http://www.ruralenergy.wisc.edu.

Cost

Certified hydronic heaters can range from $7,000 - $13,000 depending on the size of the unit. There are additional costs involved with an actual installed price.

The following is an example of the costs for a project to heat a greenhouse completed in Massachusetts for the installation of the Central Boiler brand, E-Classic model 1400 (EPA "white tag" certified), rated at 107,459 BTU/hr:

Hydronic wood furnace for greenhouse	$9,750
Heat exchanger (water to air)	$1,000
Insulated pipes	$1,000
Shipping	$350
Glycol antifreeze	$320
Installation	$1,100
Concrete footing	$90
Excavation, trench	$320
Permits and oversight	$240
Overhead (@10%)	$1,400
Total Installed Price:	**$15,570**

These costs can vary greatly depending on site conditions and if the work needs to be contracted out or can be done in-house. Estimated turn-key costs can range from $11,000 to $20,000 for a single heater with ratings between about 70,000 – 200,000 BTU/hr. A feasibility assessment can help estimate these costs, potential savings, and payback (using a cash-flow analysis).

Incentives

See the *Best Management Practices Guide's* introduction section "*Funding Opportunities for Massachusetts Farm Energy Projects*" for more information on Massachusetts Farm Energy Program (MFEP) incentives, federal tax credits, accelerated depreciation, state tax deductions, and grant opportunities.

Best Practices for Renewable Energy - Solar Electric

Technology

PV Solar Electric (Photovoltaic)

At a Glance:

- Utilizing available incentives can reduce payback to 5 – 10 years
- Be sure to maximize energy efficiency first
- Safe & reliable energy production
- Offset some or all of your electric bill
- Passive technology requires minimum maintenance

Background

Solar electric systems use solar electric panels (modules) to generate direct current (DC) electricity from the sun's radiation. This DC electricity can directly power DC equipment during the day. The DC current can also be converted to alternating current (AC) using a DC/AC inverter to power AC equipment on- and off-grid. In Massachusetts, it is more common to install a grid-tied system that is connected to the local electrical grid and utilizes net-metering. If staying off-grid, it is common to use a battery bank to store the energy during the day so that it can be used 24 hours a day, but this is a much more expensive option.

Net metering: An arrangement with the local electrical distribution company in which the energy produced from renewable sources is fed back into the utility grid and the customer is credited for the energy

Benefits

- Reduce electricity bill
- Generate power whenever there is sunlight
- Power generation corresponds to times of on-peak demand (sunny days during warmer months when additional equipment like air conditioners is running)
- Minimal maintenance since PV operates passively and silently without moving parts
- Insulate your business from future fuel price increases
- With proper installation and maintenance the solar electric modules will last a long time (25 years or longer in most cases)
- Use for remote applications such as pumps, fencing, waterers, and irrigation
- Receive public notice as an environmentally-friendly business
- Provide pollution-free electricity

Applications

Solar electric can be used to power anything that uses electricity, DC or AC and it can be on-, or off-grid.

Best Practices – Solar Electric

Solar power is a feasible source of energy for a number of agricultural practices with a large range in sizes, from a single farmstand cooler up to all on-farm energy requirements. Small to medium size solar arrays are economically viable and have been used successfully for applications with small energy requirements or, for off-grid installations, including remote areas where conventional sources of energy may not be feasible. In the northeast, livestock watering systems, small-scale trickle irrigation, and electric fencing are well suited to off-grid solar power since demand occurs during months with higher peak sun hours and warmer temperatures. Larger solar array systems used to supplement farm energy are typically longer-term investments and have also proven to be feasible with incentives.

Once properly designed and installed, solar-powered systems are simple to operate and require little maintenance. Some systems may also be mobile where needed.

To reduce system costs, energy and water conservation should be considered prior to installing a photovoltaic system. For example, for off-grid livestock watering systems, water should be stored in tanks rather than power stored in batteries. For systems requiring pumps, specially designed direct current solar-powered pumps should be selected to ensure optimal efficiency and longevity.

Limitations

The following may or may not prove to be limitations and should be considered for all projects (as applicable):

- Any local zoning, ordinances, and/or permits
  - Project may be subject to review for impact on historical, cultural, and environmental resources. Avoid systems on historical buildings and within historical districts and ground-mounted systems in or near wetlands.
  - Review permitting and easement requirements for projects on buildings or land protected by the Agricultural Preservation Restriction (APR) program. Owner has the duty to inform and possibly go through negotiations with the governing board holding the restriction.
- Whether the local distribution company allows net metering and what the buyback or credit rates are. In accordance with the Green Communities Act passed in Massachusetts in 2009, electric customers are able to sell their power back to the grid at the retail rate (up to 2 megawatts).
- What are characteristics of your existing electric service, such as voltage, number of phases, amperage rating, and whether it requires modifications to accommodate your new PV system. This may require a formal review by your distribution company.
- Amount of space for solar electric modules and whether they can be oriented to true south (e.g. orientation of building if being roof-mounted)
- Loan availability & financing
- Availability of incentives to help offset the cost of purchasing the equipment
- Availability of non-productive farmland for ground-mounted systems

Best Practices – Solar Electric

Best Practices

Site Assessment

A site assessment is essential to determine the feasibility of solar electric projects and should be done by a certified assessor. A site assessor's report should include a fatal flaw analysis to screen and identify any major obstacles to building the project. Though less extensive than a wind fatal flaw study, a PV analysis should focus on any zoning issues, by-laws or ordinances, load requirements (for roof-mounted systems, if applicable), required permits for the specific site, the local distribution company's inter-connection regulations, and the extent of electric service upgrades required to implement the project. The daily and average annual solar incidence values are generally well known and published in a number of publications, PV Watts being commonly used in the industry. The assessment should also include an economic analysis including system size, project cost (including eligible incentives), estimated annual electricity production (kWh) and value ($), offset of farm energy (required for agricultural funding), cost of electricity and estimated inflation, and Return on Investment (ROI) or a cash flow analysis.

Mounting

Ideally, a solar electric module would always be perpendicular to the sun's rays to achieve maximum production, but this can be difficult and/or costly to accomplish. There are different types of mounting structures that can be used for PV electric:

- *Fixed Array*: Fixed array is very common and the least expensive type of mount. It cannot be adjusted to increase the system's electricity production. This type is commonly used for roof mounted systems. These mounts are stationary and should be tilted at 42^0 (+/- 15^o) if possible to achieve maximum production throughout the year.
- *Fixed-Tilt Array*: This type is similar to the fixed array but instead it is put on a simple single-axis structure where the vertical tilt angle can be manually adjusted to achieve slightly higher production (about 27^o and 57^o for Massachusetts). This is usually done twice a year, in March and September to account for the higher sun angle in summer and the lower sun angle in winter. It can increase production by about 4-5% compared to a fixed array but may cost slightly more.
- *Single-axis tracking system*: Solar panels are mounted on a system so that it can either vary the panel's tilt or rotate the panels in one direction (from east to west) to automatically track the sun's position over a 24 hour period. In the evening it rotates back east to capture the morning sun. This system can increase production by up to 25%.
- *Dual-axis tracking system*: This type takes advantage of both single axis applications by combining and tracking the sun using a dual axis system. It can rotate from east to west, as well as the vertical (altitude) orientation angle. These systems track the sun over a day and over the year to take account of the lower winter sun and the higher summer sun. This system can increase production by up to 33%.

Fixed arrays (either installed on a facility's roof or ground-mounted) or pole mounted dual-axis tracking systems are the most common types of installation.

Best Practices – Solar Electric

Sizing and Production Guide

A solar electric system is generally sized to meet a certain percent of the farm's annual energy usage. There is no right answer when it comes to sizing. A system can be sized to meet any portion of a facility's energy use or sized larger if developed as an income-generating project. Size depends on the feasibility and the economic analysis of installing a system. Size also depends on other factors such as buy-back rate and limitations imposed by the utility company or incentives, such as maximum kW size and inter-connection modifications required (e.g. 2 MW max/site for net metering in MA).

A review of recent installations of PV electric systems in Massachusetts demonstrates that systems typically range between 4.4 to 250 kW in size, with the average being about 12 kW. A general rule for the physical size of the system is that production of 10 watts of electricity will need 1 square foot. A 1 kW system will therefore require 100 ft^2.

A fixed array solar electric system, rated at 1 kW, will produce about 1,220 kWh per year if it is unshaded, facing true south, and tilted at a fixed angle of 42^o to the ground in MA.

The following table outlines an estimated annual kWh production based on the solar radiation for Massachusetts on a per kW basis for different types of mounting. These values assume that the modules will not be shaded or blocked from the sun.

Mounting Type	Annual kWh Production*	% Increase Over Fixed Array
Fixed Array	1,215	---
Fixed-Tilt Array	1,270	4.5%
Single-Axis Tracking	1,525	25%
Dual-Axis Tracking	1,620	33%

*Based on PV Watts' analysis with 0.77 derate value and a 42^o fixed tilt

PV panels are able to use indirect solar energy more effectively than solar thermal applications. PV panel technology is less reliant on precise positioning than solar thermal applications: 10-15 degrees off true south and from the tilted angle of 42 degrees will not significantly affect panel performance. Also, PV systems can be mounted with a fixed tilt axis or on a single or double-axis tracking system that can track the sun daily and/or seasonally, while solar thermal systems cannot. In Massachusetts, a fixed-tilt array where the farm has the ability to tilt the panel angle seasonally has been very cost-effective. Automated tracking axis systems cost more, require routine maintenance, are generally used in high cost concentrated solar application, and are less applicable to Massachusetts farm settings.

Best Practices – Solar Electric

Maintenance

If properly installed, there is minimal maintenance involved with a fixed solar electric system. They require some cleaning to remove dust, tree sap, and/or bird droppings and should be cleaned as necessary. Removal of debris such as leaves and branches may be necessary to keep panels from being shaded. Depending on location and tilt angle, they may also need to be cleared of snow after heavy snowfalls.

The panels are typically warranted for 25 years, inverters for 10 years, and all components must be UL and IEEE approved for National Electric Code and local distribution company requirements. Electronics such as inverters must be mounted in proper environmentally rated enclosure boxes for weather protection and safety. Most active trackers use an optical sensor to determine the sun's position, and an electronic control and a motor to position the array. These are additional parts that may have to be replaced in the future. An off-grid system with a battery bank will also have additional components that may need to be replaced.

Installation

Be sure to find a reputable and NABCEP certified installer. Consider working with an installer experienced with grants and incentives targeted for this project and willing to provide related technical reports. The following links can be used to locate a local certified installer:

- http://www.nabcep.org/installer-locator-agreement
- http://www.findsolar.com/

Economic Benefit

The actual cost of installation will vary by installer, type of system (e.g. roof vs. ground), site conditions, size of system, as well as other factors. The following provides an estimated price range by size of installation (based on prices seen in Massachusetts from 2008-2010):

Size (kW)	Estimated Cost ($/kW)
< 50	$6,500 – 9,000
50-110	$6,500 – 7,500
110-250	$5,500 – 6,500
250-500	$4,500* – 5,500

*$4,500/kW is the lowest priced for a project over 500 kW

Based on recent projects installed in Massachusetts, the average cost was $7,740/kW (based on an average size of 12 kW).

Typical payback will vary greatly depending on use of available incentives. Some Massachusetts farms have found funding for 100% of their projects in past years. Without incentives, payback can be as high as 45 years. Making use of current incentives, payback can potentially be lowered to less than 5 years. Payback is often used to portray the economic benefit of large renewable projects that require financing. However, an internal rate of return (IRR) or cash flow, based on a 25-year expected life span, is a better measure of the economic benefit.

Best Practices – Solar Electric

Recommendations

- **Be energy efficient first**
- **Have an expert complete a site assessment to assess solar potential**
- **Work with an experienced solar contractor to help guide you through the installation process and to ensure a safe and reliable system**
- **Be sure the installer is certified by NABCEP (North American Board of Certified Energy Practitioners)**
- **Purchase panels with a high efficiency based on the SRCC ratings**
- **Be sure a load analysis is completed to insure sufficient engineering for a roof-mounted system**
- **Be sure to consider what financial incentives you are eligible for and consult your tax preparer when necessary**

I

Incentives

See the *Best Management Practices Guide's* introduction section "*Funding Opportunities for Massachusetts Farm Energy Projects*" for more information on federal tax credits, accelerated depreciation, state tax deductions, net metering, SRECs markets, and grant opportunities.

Technology

Solar Thermal (Solar Hot Water)

Image: Evacuated solar thermal system on a farm
Source: www.callahan.eng.pro

At a Glance:

- Conservation of hot water should be the first priority
- Can provide 40-60% (or more) of hot water needs
- Equipment has a long rated life if maintained properly
- 30-60% efficiencies compared to 12-18% for PV electric

Background

Solar thermal systems, often referred to as solar hot water (SHW), use solar collectors to capture energy from the sun and transfer it to a fluid. The fluid is typically water or a combination of water and glycol (or another anti-freeze). A system can be either an open loop system where the solar collectors directly heat the water being used or a closed loop system that indirectly heats water using a heat exchanger. Closed loop systems are more common in cold climates like Massachusetts since antifreeze is typically needed anyway to prevent freezing in the collector. A solar thermal system can be designed to heat water up to 180^{o}F or even higher.

Benefits

- One of the most effective and efficient types of renewable energy
- Minimal maintenance as it operates passively and silently without moving parts
- Create positive public perception of an environmentally friendly business
- Insulate your business from future fuel price increases
- With proper installation and maintenance, systems will last indefinitely
- Provide pollution-free hot water and/or heat

Types of Collectors

There are three main types (applications) of collectors:

- *Unglazed Collectors* (low-temp applications, 70-90^{o}F) are usually made of rubber or polymer and are used for low temperature water heating such as aquaculture facilities. They are typically only used for about 7 months of the year, since they do not work well in winter months. The benefit of this type of collector is low cost and simplicity, while drawbacks include low efficiency in cold weather, limiting it to low-temperature applications.

- *Glazed Flat-Plate Collectors* (medium-temp application, 100-140^{o}F) are housed in an insulated box to prevent heat loss and covered with a sheet of glass (glazing). This is the most common type of collector for residential hot water heating. A flat plate collector is less expensive than an evacuated tube collector but also has a high heat loss (lower efficiency) in cold weather.

Best Practices – Solar Thermal

- *Evacuated Tube Collectors (medium to high-temp applications, 140-180°F)* use sealed glass vacuum tubes with a sealed heat-pipe in each tube to capture energy. This allows for low thermal loss to the environment. A main benefit of an evacuated tube over a flat-plate collector is low heat loss (higher efficiency) in cold weather, but this can also be a drawback as these systems may not adequately melt snow during a heavy snowfall.

Applications

Solar thermal systems are most applicable for farm operations that require consistent year-round hot water or heat. Solar thermal can be used for heating domestic water or air for building heating purposes and process needs. It can also be used with an in-floor heating system. Solar thermal is applicable for offsetting electric, natural gas, and propane heating. Given current fuel prices in Massachusetts however, it is most cost-effective for offsetting electric. Possible applications include:

- Aquaculture (water heating)
- Dairy farm
- Dairy processing plant (e.g. cheese and butter)
- Greenhouses (space heating such as a hydronic under bench system)
- Process water heating
- Anywhere else hot water is used consistently

Limitations

Solar thermal may be less beneficial on farms such as dairies that already have refrigeration heat recovery (RHR) systems. A well-designed RHR unit can pre-heat water from 55°F to 110°F, overlapping with the typical 55°F to 170°F that solar thermal can provide. Combined heat recovery and solar thermal systems may still be cost-effective depending on the amount and type of hot water needed. For colder climates, heating from 110°F to 170°F using evacuated tube technology is generally more efficient than flat plate collectors due to a reduction in transmission and conduction heating losses. It is best to consider both flat plate and evacuated tube technologies to determine which is the preferable application. The following limitations should be considered for any project (as applicable):

- Any local zoning, ordinances, and/or permits
    - Project is subject to review for impact on historical, cultural, and environmental resources. Avoid systems on historical buildings and within historical districts and ground-mounted systems in or near wetlands.
    - Review permitting and easement considerations for projects on buildings or land protected by the Agricultural Preservation Restriction (APR) program. Owner has the duty to inform and possibly go through negotiations with the governing board holding the restriction.
- Amount of space for solar collectors and whether they can be oriented to the south (e.g. orientation of roof if being roof-mounted)
- Loan availability & financing
- Availability of incentives to help offset the cost of purchasing the equipment
- Availability of non- productive farmland for ground-mounted systems

Best Practices – Solar Thermal

Best Practices

Site Assessment

A site assessment is essential to determine the feasibility of solar thermal projects and should be done by a certified assessor. A site assessor's report should include the average annual solar access as well as any other restrictions or limitations imposed by the site. It should also include an economic analysis including system size, project cost (including eligible incentives), estimated annual production (BTUs) and value ($), cost of electricity and estimated inflation, ROI, and/or a cash flow analysis.

Mounting

The panel should be mounted at an angle close to the latitude of the location (+/- 15^o). This is roughly 42^o for Massachusetts with 0^o being horizontal (flat) with the ground and 90^0 being perpendicular. Latitude gives the best yearly average, but the angle can be modified to meet a higher demand in winter or summer at the expense of losing efficiency in the other season. A higher angle (closer to 90^0) would give a better performance in winter when the sun is lower.

Sizing and Production Guide

Conservation and efficiency of hot water should be a farm's first priority. An inventory of hot water usage and possible ways to conserve or be more efficient should be conducted. Installing a high efficiency water heater (like an on-demand unit), insulating hot water pipes, and repairing leaking pipes and taps can reduce energy needs for heating water. If hot water is being discharged somewhere else on site, consider a heat exchanger (anywhere from 30-70% efficient). Decreasing the amount of hot water that needs to be heated not only saves money but can reduce the cost of a SHW system.

Solar hot water systems are typically designed to meet 40-60% of the hot water needs and the back-up heating equipment will heat the rest. Sizing the system for seasonal peak demand means over-sizing the system for low-use periods, when excess heat needs to be removed, either by radiating it back to the atmosphere at night, covering a portion of the solar collectors during the summer months, or draining water. This can help meet a higher percent of the hot water needs at peak demand, but results in a higher initial cost and a longer payback since the system is not being utilized to its full potential 100% of the time. An analysis should be completed first to determine if it makes sense to over-size the system.

Actual production is dependent on the efficiency of the collector. For performance data of collectors, refer to the Solar Ratings and Certification Corporation (SRCC) website located at: http://www.solar-rating.org/.

It is important to pick a collector appropriate to the farm's needs. Each type of collector has a range of efficiencies depending on the difference of temperature from well water (50-55 degrees) to the desired temperature.

Best Practices – Solar Thermal

A site assessment should be conducted to determine the actual size and design of the system. There are many factors that contribute to the actual performance such as: heating loads, time of use, location, solar orientation of panels, shading and panel efficiencies as well as other factors. Typically, for system sizing. computer modeling programs and weather data for the nearest location are used that can take the various factors into account.

Installation

Be sure to find a reputable installer who is NABCEP (North American Board of Certified Energy Practitioners) certified. Consider working with an installer experienced with grants or incentives targeted for this project and willing to provide related technical reports. The following links can be used to locate a local, certified installer:

- http://www.nabcep.org/installer-locator-agreement
- http://www.findsolar.com/

Recommendations

- **Be water efficient first and use rejected heat from other equipment where applicable**
- **Have an expert complete a site assessment and design the system to meet hot water demands**
- **Be sure the installer is certified by NABCEP. Only purchase collectors certified by the Solar Rating and Certification Corporation (SRCC)**
    - **www.solar-rating.org**
- **Purchase panels with a high efficiency (BTUs/ft^2) for the given category based on SRCC ratings**
- **Be sure a load analysis is completed to ensure sufficient engineering for roof mounted systems**

Economic Benefit

Cost of installation will vary by installer, site conditions, size of system, as well as other factors. Typical prices based on recent installations in Massachusetts ranged from \$125-150/ft^2.

Typical payback will vary greatly depending on use of available incentives. Some Massachusetts farms have found funding for 100% of their projects in past years. Without incentives, payback can be as high as 25 years. Making use of current incentives, payback can potentially be lowered to less than 5 years. Payback is often used to portray the economic benefit of large renewable projects that require financing. However, an internal rate of return (IRR) or cash flow, based on a 25-year expected life span, is a better measure of the economic benefit.

Best Practices – Solar Thermal

Incentives

See the *Best Management Practices* Guide's introduction section *"Funding Opportunities for Massachusetts Farm Energy Projects"* for more information on Massachusetts Farm Energy Program incentives, federal tax credits, accelerated depreciation, state tax deductions, net metering, SRECs markets, and grant opportunities.

Other Photos & Schematics

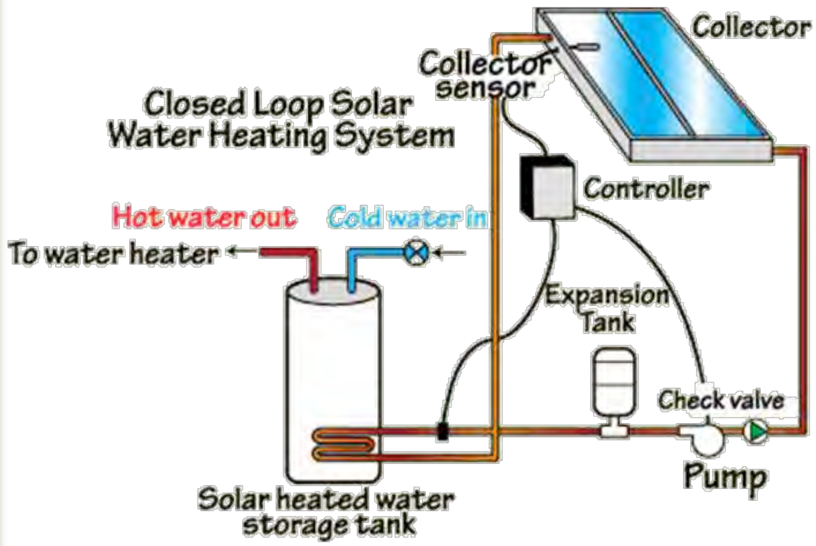


Figure: Schematic of a typical solar hot water system[ii]

Technology

Wind (small-scale)

At a Glance:

- Using available incentives can reduce payback to 5 – 10 years
- Be sure to maximize energy efficiency first
- Offset some or all of your electric bill
- A site assessment is necessary as wind speed has a huge effect on output

Background

What is wind power and how does it work?

Wind turbine rotor blades capture the force of the wind's velocity, causing the blades to rotate. The blades are mounted to a shaft that is connected to a generator. As the rotor blades turn, they rotate an electric generator (turbine) that produces electricity. In grid-tied systems, the electricity generated by the generator then goes through an inverter to produce electricity with the correct frequency and voltage necessary to be used on the grid or at the facility. Grid-tied systems can be eligible for net metering, where excess electricity generated is exported back onto the grid and purchased by the electric distribution company. In Massachusetts, net-metering laws require that the investor owned distribution companies NGRID, NSTAR, WMECO and Unitil purchase the electricity at retail rates.

Wind turbines can work well for agricultural settings with appropriate wind resources because they need open areas like cropland, hilltops or pastures to operate efficiently, yet take up very little land. In Massachusetts, adequate wind resources are typically associated with ridgetops and in coastal areas. Grid-connected systems are most common, but off-grid energy production is also possible using a battery bank to store the energy. Small-scale wind is typically rated at 100 kW and less, while utility size wind turbines can range up to 2 MW (2000 kW).

Benefits

- Provide pollution-free electricity
- Reduce electricity bill
- Generate power whenever there is adequate wind
- Create positive public perception as an environmentally friendly business
- Insulate your business from future fuel price increases
- With proper installation and maintenance, wind turbines should last 20 years or longer (typical warranty, however is 5 years)

Best Practices – Wind

Applications

Wind turbines are most applicable in open areas such as fields, ridge tops, and coastal areas where there are few obstructions that can cause turbulence. There is a large range of turbine sizes to meet most applications.

Limitations

The following may or may not prove to be limitations and should be considered for all projects (as applicable):

- Any local zoning, ordinances, and/or permits
  - Project is subject to review for impact on historical, cultural, and environmental resources. Avoid installing systems within historical districts or near wetlands
  - Consider permitting and easement considerations for projects on buildings or land protected by the Agricultural Preservation Restriction (APR) program. Owner has the duty to inform and possibly go through negotiations with the governing board holding the restriction
  - Consider any conflicts with the Massachusetts Audubon Important Bird Areas (IBAs)
  - Consider any conflicts with FAA airspace and FCC communications interference issues
- Whether the local distribution company allows net metering and what the buyback or credit rates are. In accordance with the Green Communities Act passed in Massachusetts in 2009, electric customers are able to sell their power back to the grid at the retail rate (up to 2 megawatts)
- Review characteristics of your existing electric service, such as voltage, number of phases, amperage rating, and whether it requires modifications to accommodate your new wind turbine. Your distribution company may need to do a formal review of the service.
- Amount of space for the wind turbine and access road if necessary
- Loan availability & financing
- Availability of incentives to help offset the cost of purchasing the equipment
- Availability of non-productive farmland for installation
- Minimum wind speed of 6.0–6.5 m/s at 70m elevation is needed to meet the Massachusetts Clean Energy Center (MassCEC) Wind base eligibility requirement.

Not all locations are suitable for a wind system. Wind speed, terrain, proximity of buildings, trees, and other obstacles can all affect performance. A wind assessment is necessary to determine if a wind system is applicable to a specific location. Depending on the scale of the project, this assessment can be a simple review of existing wind maps or may require onsite wind data measurement.

You can find out about the zoning restrictions in your area by calling the local building inspector, select board, or planning or zoning board. Additional limitations may be imposed by neighbors or the local community, often referred to as NIMBY (Not-In-My-Back-Yard). If considering wind, it is important to work with all parties who may be affected.

Best Practices -- Wind

Another limitation to wind is the difficulty in estimating the annual energy output of a wind turbine due to the huge variability and inconsistency of wind speed. There have been cases where small-scale wind turbines on Massachusetts farms did not meet the production estimates.

Another part of the application process is negotiating a grid-tie agreement with the utility company. Refer to the applicable utility website or contact them directly to find out more information.

Please note: Depending on the size, a wind turbine may require a long-term commitment in terms of financing, maintenance, and contractual obligation.

Best Practices

Site Assessment

A wind site assessment by a certified assessor is a must. The assessor will make a site visit to discuss plans and goals for installing a wind turbine as well as examine the topography, density and height of surrounding terrain and buildings, distance to 3-phase power (if grid-connected), and future development plans (any planned increase in electricity usage), among other things. MassCEC can help provide financial support for feasibility studies (75% cost-share). A site assessor's report should include the following:

- A fatal flaw analysis which will identify any fatal flaws including lack of adequate wind speed, FAA needs, local zoning and ordinances, required permits, any local, state or federal historical requirements, endangered species, bird migration potential and any other environmental impacts. A fatal flaw analysis will determine if the project can likely be implemented.
- Details on any land area that needs to be cleared or made available for access
- Average wind speed, direction and turbulence for site
- Minimum recommended tower height
- Turbine recommendations
- Current energy use and cost
- Cash flow analysis (cumulative and annual for 20 years) including estimated turnkey project cost, annual operating & maintenance (OM) costs, annual energy output (AEO – rated in kWh) and value ($), offset of farm energy (required for agricultural funding), and potential grants and incentives

Mounting

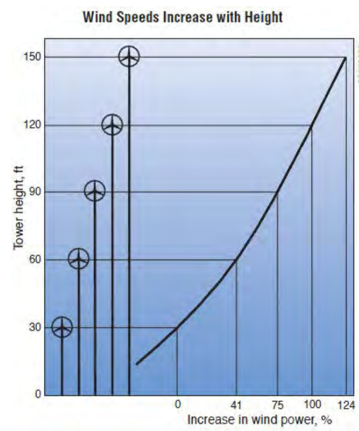
Turbine Selection

A site assessor should be informed of qualified turbines to meet any requirements of an incentive or grant. In a recent study there are at least 74 wind turbine manufacturers in the USA offering products, but only 14 of the companies "have begun sales," meaning they actually have something to sell other than a simulation or prototype[iii]. It is important to research suitable companies with a history of manufacturing and supporting wind-electric systems in order to choose a reliable system. Be sure to talk to both experts and end-users and refer to available publications.

Best Practices – Wind

If considering an international purchase, consider any challenges to obtaining technical support and maintenance expertise.

Towers



Wind speed increases with height. In general, the higher the tower, the more electricity the wind turbine will produce. Height can also help decrease turbulence from nearby obstructions that can result in significantly reduced power production and potential damage to turbines. As a general rule of thumb:

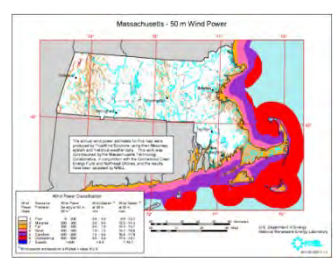
Wind turbines should be mounted at least 30 feet above any obstructions to wind within a 500 foot radius.

Some turbines come with only one tower height while others can come in sections (commonly 20'). There are two basic types of towers: self-supporting (tubular or lattice) and guyed. Lattice and guyed are common for small-scale systems because they are typically less expensive and easier to install. They consist of lattice sections, pipe or tubing depending on design, and supporting guy wires. There must be room available to install the guy wires (guy radius is typically ½ - ¾ of tower height)[iv]. A 120' (36 meters) tower has been a common height for small scale turbines, as it provides adequate access to wind and is still cost-effective to purchase.

The optimal size of a turbine and height of a tower is a function of terrain, local wind speed, cost of varying turbine sizes, cost of varying tower heights, and the kWh rate from the local utility company. It is essential to work with a professional to determine the optimal setup.

Sizing and Production Guide

Determining Wind Speed



Wind speed, direction and turbulence are the most important factors to estimate energy production. Wind speed can vary significantly over an area of just a few miles because of local terrain influences. Wind direction is usually seasonal yet predominant directions can be determined. Wind turbulence is mostly effected by nearby topography such as tall trees and buildings. Turbulence is important because it is a measure of useful wind; the more turbulent wind is, the less useful it is for power generation. The estimated wind speed will be determined by the wind site assessor by looking at the variables involved. A wind map of Massachusetts is available for wind speeds at 50 meters:

- http://www.windpoweringamerica.gov/maps_template.asp?stateab=ma
  Disclaimer: This map should only be used as an approximation.

Best Practices – Wind

Also, the Massachusetts Clean Energy Center (MassCEC) has a Commonwealth Wind Energy and Siting Tool (CWEST) that will estimate the wind speed for a given latitude and longitude. More advanced users can also estimate the annual electricity output (AOE) given certain site characteristics for a variety of wind turbines at http://cwest.cadmusweb.com.

Consider purchasing or renting an anemometer. It can help to determine the wind speed for a specific site location and can be cross-referenced with the estimated wind speed from CWEST. They can be rented for about $90/month.[v]

Turbine Sizing and Estimated Annual Electricity Output (AOE)
Any wind turbine manufacturer should provide a certified power curve for each of their turbines. It is best if this power curve is certified by an independent testing source. The power curve provides important operating characteristics of the wind machine, including cut-in and cut-out wind speeds, and the kW produced at different wind speeds. When comparing turbines, it is important to compare the annual electricity output (AOE) values. These should be available from the manufacturer or available for comparison in such publications as the 2010 Wind Generator buyer's guide from Home Power[vi]. Also, the above website from MassCEC has a tool to predict the electricity production, but should only be used as an approximation, since actual values will vary due to site conditions and actual wind speed.

Maintenance
Wind turbines require annual maintenance conducted by a professional. Be sure maintenance costs are included in the financial analysis. Typical maintenance includes (but is not limited to) the following:

- Visual & thermo-graphic inspection
- Oil changes and lubrication
- Major component work on rotor blades, hub, drive train
- Blade tip condition assessment and repair

Installation
Be sure to find a reputable installer. The North American Board of Certified Energy Practitioners (NABCEP) has recently implemented a certification program for small wind installers (systems under 100 kW). Work with the energy auditor and turbine manufacturer to discuss the installation process.

Best Practices -- Wind

Recommendations

- **Be energy efficient first**
- **Have an expert complete a site assessment to determine any fatal flaws and assess wind and economic potential**
- **Work with an experienced wind contractor to help guide you through the installation process and to ensure a safe and reliable system**
- **Be sure to consider any limitations that may prevent the successful installation of a wind turbine**
- **Be sure to research available wind turbines, performance, and tower heights. Talk to experts and other end-users and consult the reference materials in "Additional Resources"**
- **Be sure to consider what financial incentives you are eligible for and consult your tax preparer when necessary**

Economic Benefit

A site assessor should be able to estimate the cost of a turnkey system, but the report will need to be submitted to a wind turbine manufacturer/installer for an actual quote. Costs can range from $4,000 for a small turbine estimated to produce 2,000 kWh annually (at a wind speed of 11 mph) to $525,000 for a 100 kW system, rated to produce 125,000 kWh annually (at a wind speed of 11 mph). A commonly recommended turbine, rated at 15 kW, which would produce about 23,000 kWh, will cost about $100,000. As a very rough estimation, based on implemented projects in Massachusetts, the average installed cost will be about $7,000/kW (based on an average size of 17 kW).

Typical payback will vary greatly depending on use of available incentives. Without incentives, payback can be as high as 30 years. With incentives, payback can potentially be lowered to 5 – 10 years. Payback is often used to portray the economic benefit of large renewable projects that require financing. However, an internal rate of return (IRR) or cash flow, based on the expected life of the equipment, is a better measure of the economic benefit.

Incentives

See the *Best Management Practices Guide's* introduction section *"Funding Opportunities for Massachusetts Farm Energy Projects"* for more information on federal tax credits, accelerated depreciation, state tax deductions, net metering, RECs markets, and grant opportunities.

Best Practices -- Wind

Additional Sources

Please see the following links for additional information on wind:

- Commonwealth Wind Program – MicroWind: http://www.masscec.com
- Small Wind Electric Systems – A Massachusetts Consumers Guide: http://www.windpoweringamerica.gov/pdfs/small_wind/small_wind_ma.pdf
- Wind Powering America: http://www.windpoweringamerica.gov/
- University of Massachusetts Wind Energy Center: http://www.umass.edu/windenergy/

Schematic

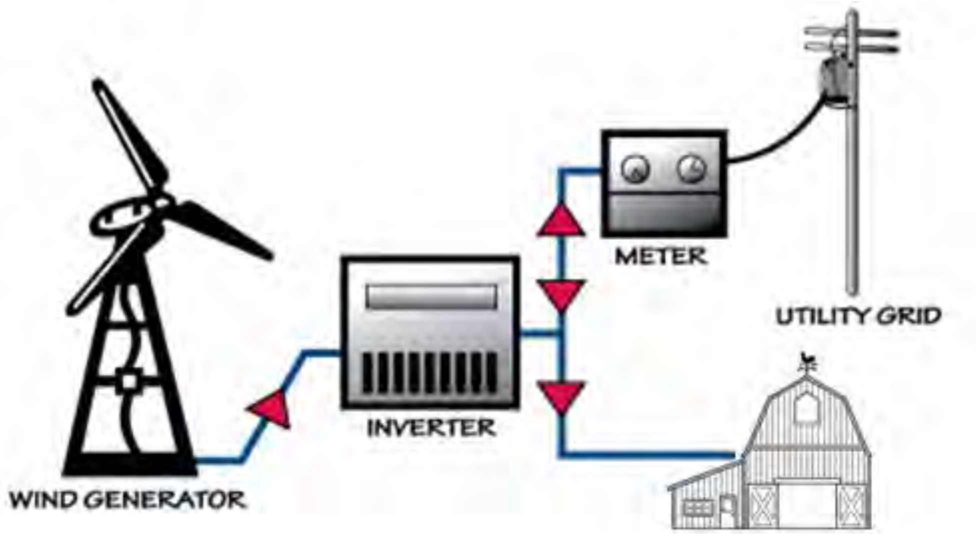


Figure: Simplified schematic of a grid-connected wind turbine

Funding Opportunities for Massachusetts Farm Energy Projects: Efficiency & Renewables

Where to Start – Information & Resources

Massachusetts Farm Energy Program (MFEP)
MFEP provides technical assistance and funding referrals for farmers looking for financial resources to support energy efficiency or renewables projects. MFEP staff are up-to-date on the evolving funding opportunities and offer an initial one-stop shop for funding resources for farm energy projects. Contact MFEP staff at (413) 256-1607.

Farm Energy Discount Program
All **agricultural ratepayers** in Massachusetts enjoy a **mandated 10% reduction on their energy bills** for electricity and natural gas supplied by public utilities as a result of legislation enacted to restructure the utility industry. Individual and corporations that are "principally and substantially engaged in the business of production agriculture or farming for an ultimate commercial purpose" are eligible. The Massachusetts Department of Agricultural Resources (MDAR) is the state agency responsible for determining farm eligibility for the Farm Energy Discount. A two-page application is available at http://www.mass.gov/agr/admin/farmenergy.htm or contact Linda Demirjian, Office Manager, MDAR, at (6l7) 626-1733.

Massachusetts Department of Agricultural Resources (MDAR)
MDAR offers **energy related grant opportunities** through the Ag-Energy Grant Program in May-June each year, in addition to farm viability and business development grants that may consider energy projects as a component.

MDAR also offers **support for farms** interested in energy efficiency, conservation, and renewables through their renewable energy coordinator position. More information and technical resources are available at http://www.mass.gov/agr/programs/energy/index.htm. To discuss the technical aspects of proposed energy projects, contact Gerry Palano, MDAR Renewable Energy Coordinator at 617-626-1706 or Gerald.Palano@state.ma.us.

DSIRE - Database of State Incentives for Renewables and Efficiency
This online database provides up-to-date resources on financial incentives for renewables and efficiency projects from state and federal sources, many of which are applicable to farm businesses. Search the Massachusetts pages for more information at www.dsireusa.org.

Installers and Contractors
Independent equipment installers, dealers, and contractors are a good source of information related to financial incentives for energy projects. Particularly in the case of renewable energy, installers need to track funding programs and realistically estimate how they affect the payback period for the project in order to maintain a competitive advantage in their field.

Energy Efficiency Financial Resources

State Resources

Public Utility Energy Efficiency Programs
Customers of investor-owned ("public") utility companies pay into conservation, efficiency, and renewable energy funds and therefore have access to energy efficiency programs. These "public" energy conservation programs are regulated by the MA Department of Public Utilities. Typically utilities offer **energy assessments**, performed by employees or contractors, as well as **financial incentives** (cost-share) on cost-effective energy efficiency measures.

There are four investor-owned electric utility companies in Massachusetts: National Grid, NSTAR, UNITIL (Fitchburg Gas & Electric), and Western Massachusetts Electric Company. In addition, Cape Light Compact operates the regional energy efficiency program for the Cape and islands. Natural gas companies include Berkshire Gas, Columbia Gas of Massachusetts (formerly Bay State Gas), National Grid (formerly Keyspan Gas), and NSTAR. For contact information related to farm energy assessments and incentives, go to http://www.berkshirepioneerrcd.org/mfep/existing.php or call the Massachusetts Farm Energy Program.

Municipal Utilities
Customers that are serviced by the 40 municipal electric and gas utility departments in the state typically do not pay into conservation or renewable energy funds. Some municipal utility companies have developed fee for service audit programs. Contact your individual municipal utility company to see what programs are available.

Federal Resources

USDA-Rural Development's (RD) Section 9007: Rural Energy for America Program (REAP)
USDA-Rural Development administers competitive grants for energy efficiency and renewable energy projects at 25% of eligible project costs, as well as guaranteed loans, to farmers and rural small businesses. The Massachusetts Farm Energy Program offers informational sessions and grant writing assistance to farmers for applying to this program, in cooperation with Berkshire-Pioneer RC&D, the Massachusetts Woodlands Institute, and USDA-Rural Development. The annual application deadline is generally in the spring. For information, go tohttp://www.rurdev.usda.gov/rbs/farmbill/index.html or contact your local USDA-Rural Development Area Office.

Energy efficiency project applications to REAP require an energy assessment or audit, and renewable projects require technical reports from installers. MFEP offers technical and financial assistance for energy audits but farmers must apply for an audit prior to the REAP application announcement. In addition, MFEP strongly encourages producers to work on preparing the application during slower seasons on the farm.

USDA-Environmental Quality Incentives Program (EQIP)
Under the 2008 Food, Conservation and Energy Act the Natural Resources Conservation Service (NRCS) can provide eligible producers with program support through the Environmental Quality Incentives Program (EQIP) to implement cost-effective and innovative practices that improve air quality. Individuals, groups and entities who own or manage farmland, pastureland or non-industrial forest land are eligible to apply. Producers with an annual minimum of $1,000 of agricultural products produced and/or sold from their operation are eligible to apply. For 2009 EQIP provided funding for specific conservation practices related to anaerobic digestion, greenhouse energy screens and horizontal air flow, and cranberry auto-start systems. More information about EQIP can be found at: http://www.ma.nrcs.usda.gov/programs/airquality/index.html or contact your local NRCS office.

Renewable Energy Financial Resources

State Resources

Department of Public Utilities (DPU) Net Metering

Net metering for wind, solar and agricultural energy installations encourages public utility customers to install solar panels and wind turbines, by allowing them to earn credit on their electric bills if they generate more power than they need. Farms are also encouraged to install additional renewable technologies such as anaerobic digesters.) Under the Green Communities Act signed by Governor Patrick in 2008, utility companies must compensate their customers for up to 2 megawatts of excess electricity at the retail rate rather than the lower wholesale rate. Additionally, customers may allocate their credits to other customers. To find out how you can apply for net metering contact your local eligible utility (NGRID, NSTAR, WMECO or UNITIL), or work through your renewable energy installer.

Municipal utility customers planning to install a renewable energy project to produce electricity will need to contact their suppliers to review net metering and interconnection policies.

Massachusetts Clean Energy Center (MassCEC)

The Green Jobs Act of 2008 created the Massachusetts Clean Energy Center (MassCEC) to accelerate job growth and economic development in the state's clean energy industry. The Renewable Energy Generation division of MassCEC is responsible for supporting renewable energy projects throughout the Commonwealth.

MassCEC has awarded funds to hundreds of businesses, towns, and non-profits for feasibility and/or design and construction of solar panels, wind turbines, biomass systems, hydroelectric systems, and other clean energy systems. Contact MassCEC to learn about current programs like Commonwealth Wind and Commonwealth Solar at www.masscec.com or call (617)315-9355.

Renewable Energy Certificates (RECs)

RECs are a means by which the environmental benefits, also known as the renewable attributes, of energy production by eligible renewable energy technologies can be sold to retail electric suppliers (RES) who are required to buy a minimum amount of these attributes to meet Massachusetts' renewable portfolio standard (RPS) requirements. For more details regarding eligible technologies and how prices are determined, refer to the MA Department of Energy Resources (DOER).

Solar Renewable Energy Certificates (SRECs)

The SRECs program is a market-based incentive program to support the development of 400 MW of solar photovoltaic (PV) infrastructure across the Commonwealth. SRECs are a means by which solar energy producers can sell the environmental attributes of solar generation to public utilities which are required to buy a minimum amount to meet Massachusetts' renewables portfolio standard (RPS) requirements. The sale of these certificates allows for a consistent cash flow for a ten-year period.

State Resources (cont.)

Massachusetts State Tax Deduction
Businesses in Massachusetts may deduct from net income, for state excise tax purposes, the installed cost of renewable energy systems. See www.dsireusa.org or contact a tax consultant for more details.

Federal Resources

USDA-Rural Development's (RD) Section 9007: Rural Energy for America Program (REAP)
The Section 9007 of the 2008 Farm Bill provides funding for renewable energy systems and energy efficiency improvements. USDA-Rural Development administers these funds and offers competitive grants at 25% of eligible project costs, as well as guaranteed loans, to farmers and rural small businesses. The Massachusetts Farm Energy Program offers informational sessions and grant writing assistance to farmers for applying to this program, in cooperation with Berkshire-Pioneer RC&D, the Massachusetts Woodlands Institute, and USDA-Rural Development. The annual application deadline is generally in the spring. For more information, go to http://www.rurdev.usda.gov/rbs/farmbill/index.html, or contact your local USDA-Rural Development Area Office.

Business Investment Tax Credit (ITC) and American Recovery and Reinvestment Act of 2009 (ARRA)
The federal business energy investment tax credit available under 26 USC § 48, and expanded by the Energy Improvement and Extension Act of 2008 (H.R. 1424) in October 2008 and the American Recovery and Reinvestment Act of 2009 in February 2009, provides tax credits for a range of renewable energy projects, ranging from 10%-30% of the eligible costs of renewable energy projects.

Deadlines: Credit Termination Dates vary by technology, but are generally available for eligible systems placed in service before January 1, 2017 (with the exception of large wind 1/1/13 and biomass 1/1/14).

U.S. Department of Treasury Renewable Energy Grants
Instead of taking the energy investment credit (described above), a taxpayer can apply for a cash payment valued at 30% of the total system cost for solar and wind systems through the Department of Treasury (section 1603 Cash Payment). More information is available at http://www.treas.gov/recovery/1603.shtml.
Deadline: construction must begin by 12/31/2011

Federal Accelerated and Bonus Depreciation
Under the federal Modified Accelerated Cost-Recovery System (MACRS), businesses may recover investments in certain property through depreciation.

Next Steps

Reviewing the *Massachusetts Farm Energy Best Management Practices Guide* is the first step in reducing energy use and saving money. Below are some steps to keep in mind for successful energy management.

Steps to Successful Energy Management

1. ***Learn about energy conservation, energy efficiency, and renewable energy***
   Learning about your energy use and ways to reduce it or supplement it with renewable energy is the first step. There is much information available about reducing energy use as well as case studies of farms that have taken action.

2. ***Apply for a farm energy audit or renewable energy assessment***
   An energy audit can help determine where energy is being wasted by inefficient equipment and practices and can recommend solutions. After reading about the MFEP Audits & Incentives Program on the Berkshire Pioneer RC&D website, complete an application to apply for an energy audit or renewable energy assessment. The link to the application is: www.berkshirepioneerrcd.org/mfep/forms/application.php.

3. ***Apply energy conservation practices***
   The easiest and most cost effective method of achieving energy savings is through energy conservation. Energy conservation means using energy wisely and eliminating energy waste, such as running a heater or a ventilation fan when it's not necessary.

4. ***Apply recommended energy efficiency practices***
   Energy efficiency means using less energy to produce the same end result. This manual focuses on conventional energy efficiency measures using current applicable technology. Energy efficiency measures should be taken before considering renewable energy. Reducing the amount of energy used is more cost effective than purchasing renewable energy to power inefficient devices.

5. ***Focus on Time-of-Use management (for cost savings, if applicable)***
   With proper Time-of-Use energy management, it is possible for agricultural producers to reduce their energy bills. Load demands change dramatically throughout the day, but utility companies must have the capacity to provide enough electricity for on-peak demand (typically aligning with summer months and daylight hours). In order to spread out this peak demand more evenly over the 24-hour day, electric utility companies provide a Time-of-Use (TOU) pricing structure. In a TOU billing structure, kWh prices are increased during on-peak hours and are reduced during off-peak hours to encourage customers to change behavior by using energy intensive equipment outside of peak hours.
6. ***Installation of Renewable Energy***
   After the previous steps have been exhausted, renewable energy is the final step. Renewable energy has a much lower environmental impact than conventional sources of energy production and decreases the US dependence on a fossil fuel economy. It also helps stimulate the economy and create job opportunities. Money spent on renewable energy is spent on materials and staff that build and maintain the equipment instead of importing non-renewable fossil fuels. This manual focuses on solar thermal, photovoltaic, wind, and biomass. Other technologies include, but are not limited to, anaerobic waste digesters (biogas), geothermal, and hydro.

Disclaimers

- Mention of trade names and products is for information purposes only and constitutes neither an endorsement of, recommendation of, nor discrimination against similar products not mentioned.
- Although this guide contains research-based information and the contributors have used their best efforts in preparing this guide, the contributors make no warranties, express or implied, with respect to the use of this guide. Users of this guide maintain complete responsibility for the accuracy and appropriate application of this guide for their intended purpose(s).
- In no event shall the contributors be held responsible or liable for any indirect, direct, incidental, or consequential damages or loss of profits or any other commercial damage whatsoever resulting from or related to the use or misuse of this guide.
- The contributors emphasize the importance of consulting experienced and qualified consultants, advisors, and other business professionals to ensure the best results.
- Project costs presented in this report are estimates only, based upon available pricing information at the time of compiling this report. Actual costs will likely vary due to many different variables.

Energy and Fuel Prices

Energy and fuel prices are constantly fluctuating. Actual prices will affect the economic feasibility of a project. The following energy prices have been used for purposes of the calculations throughout this manual:

- $0.15/kWh
- $1.10/therm
- $2/gallon propane (LP)
- $2.5/gallon fuel oil
- $200/full cord of wood (measured as 4' x 4' x 8')

For more information, contact the Mass Farm Energy Program at Berkshire-Pioneer RC&D:
www.berkshirepioneerrcd.org/mfep or 413.256.1607

References

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Massachusetts Farm Energy Program

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